FIG. 1

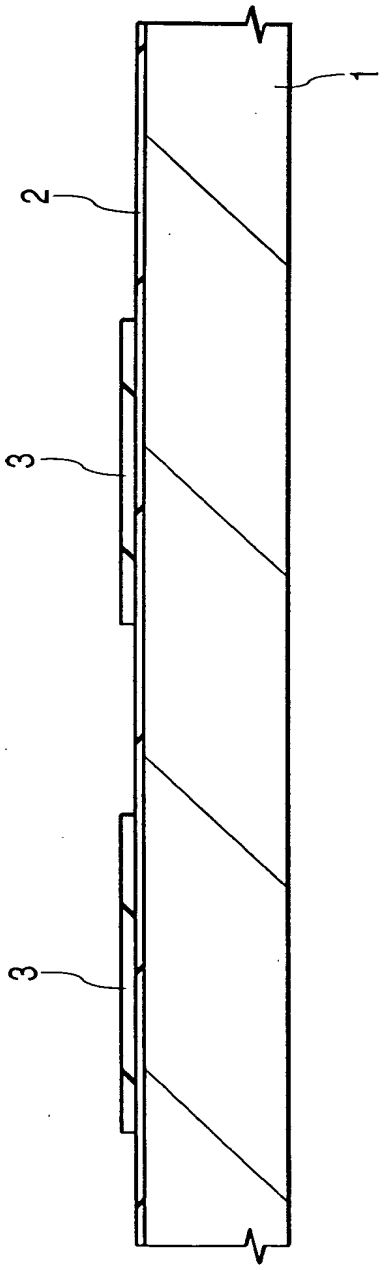


FIG. 2

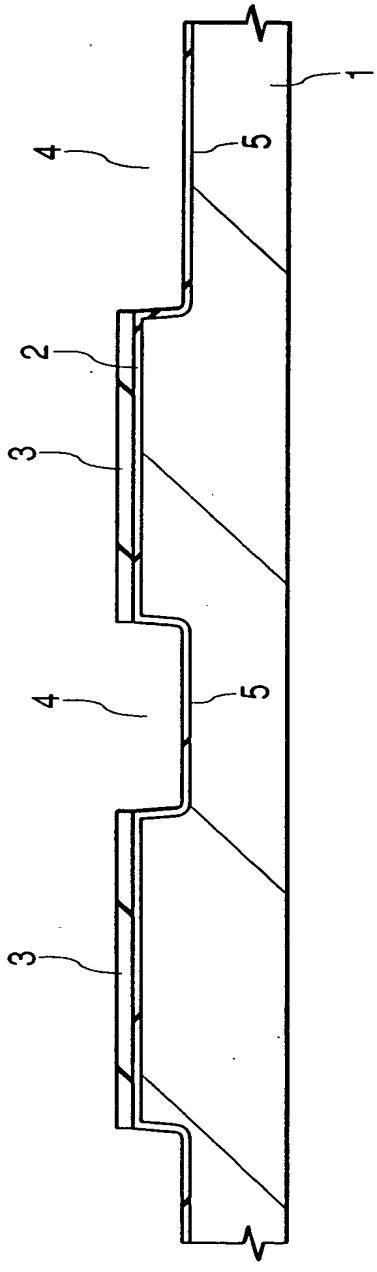


FIG. 3

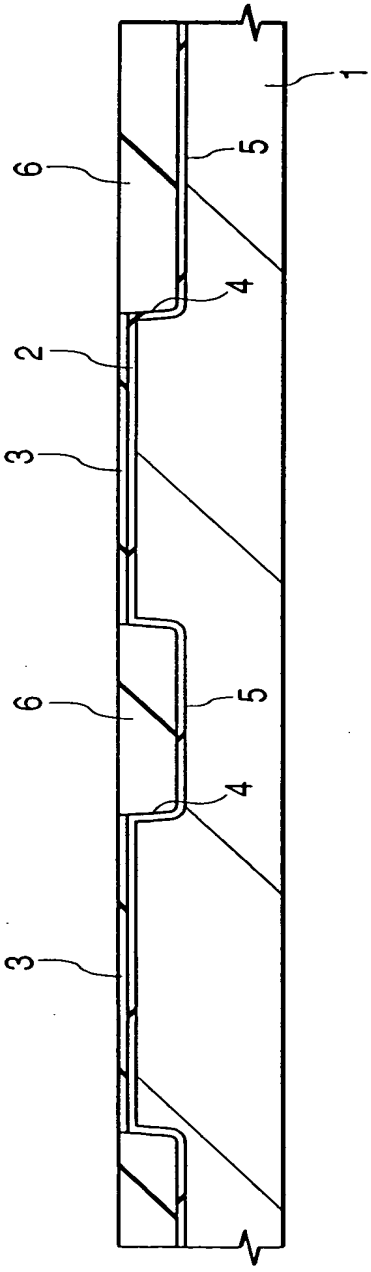


FIG. 4

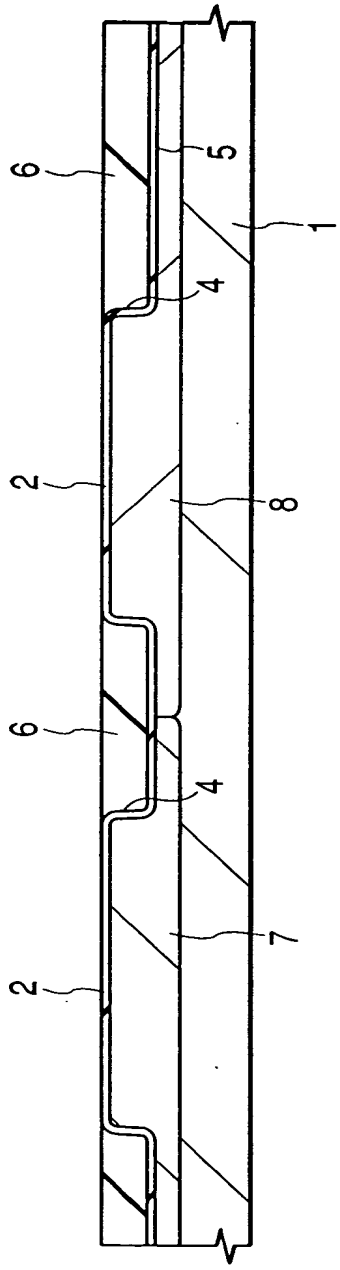


FIG. 5

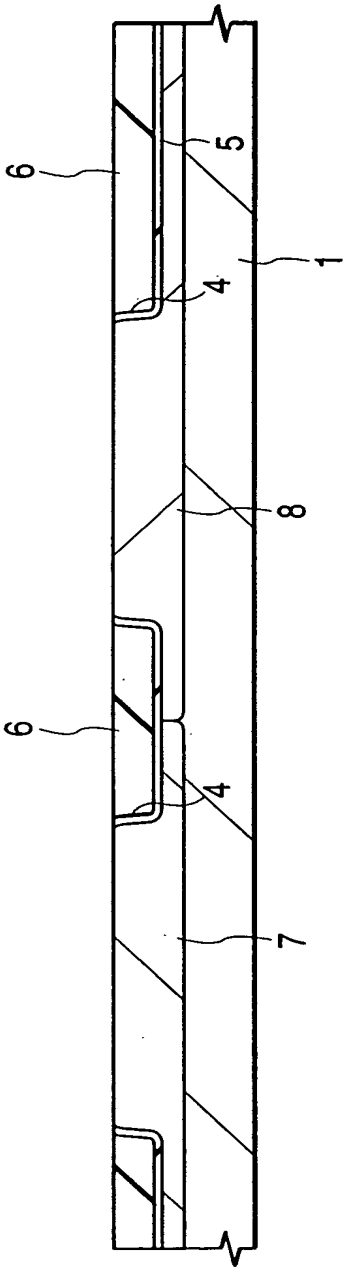


FIG. 6

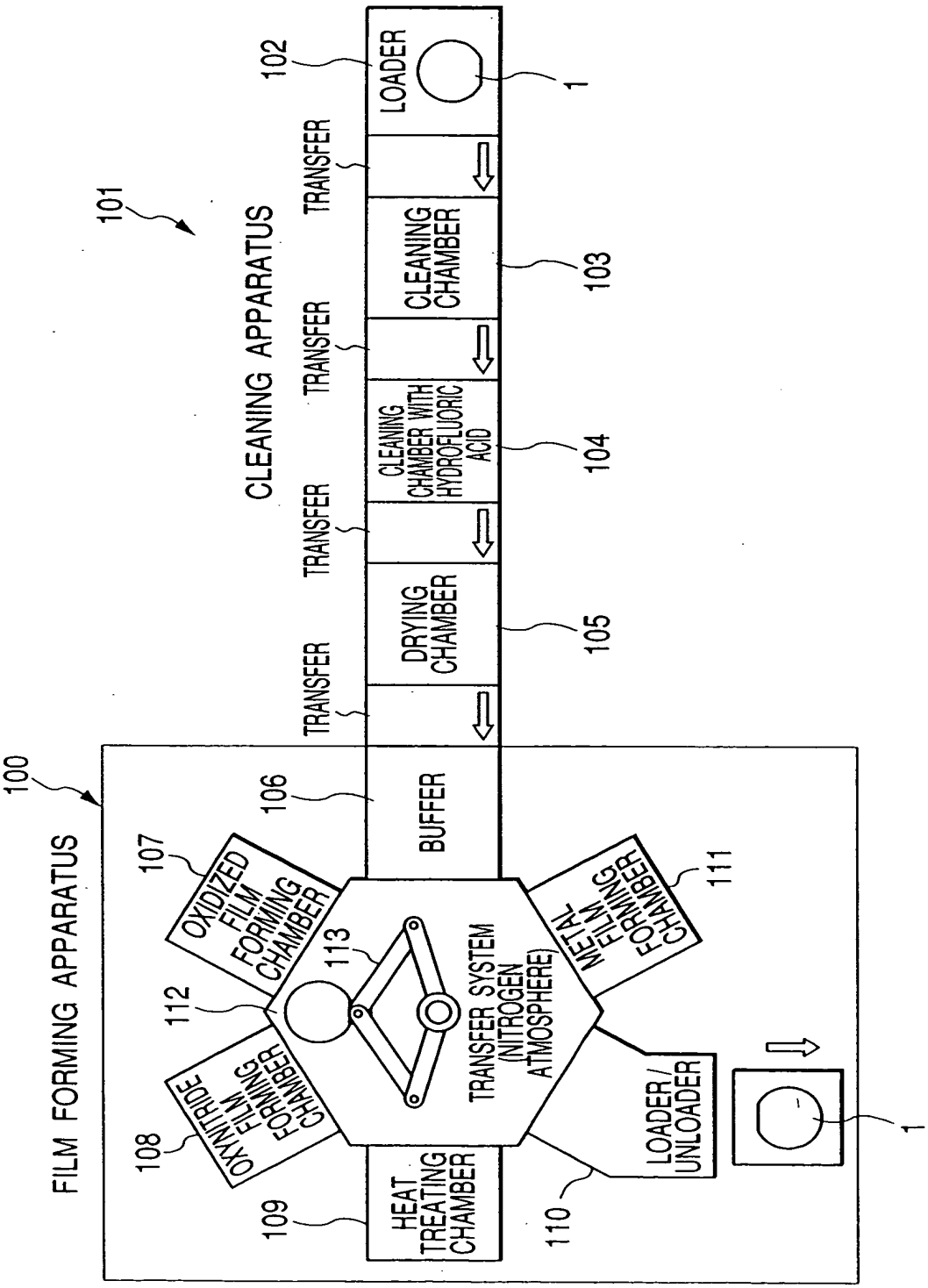

101
CLEANING APPARATUS
102
LOADER
1
TRANSFER
CLEANING CHAMBER
103
CLEANING CHAMBER WITH HYDROFLUORIC ACID
104
DRYING CHAMBER
105
BUFFER
106
100
FILM FORMING APPARATUS
107
OXIDIZED FILM FORMING CHAMBER
112
113
TRANSFER SYSTEM (NITROGEN ATMOSPHERE)
111
METAL WIRING FORMING CHAMBER
108
OXYNITRIDE FILM FORMING CHAMBER
109
HEAT TREATING CHAMBER
110
LOADER/ UNLOADER

FIG. 7(a)

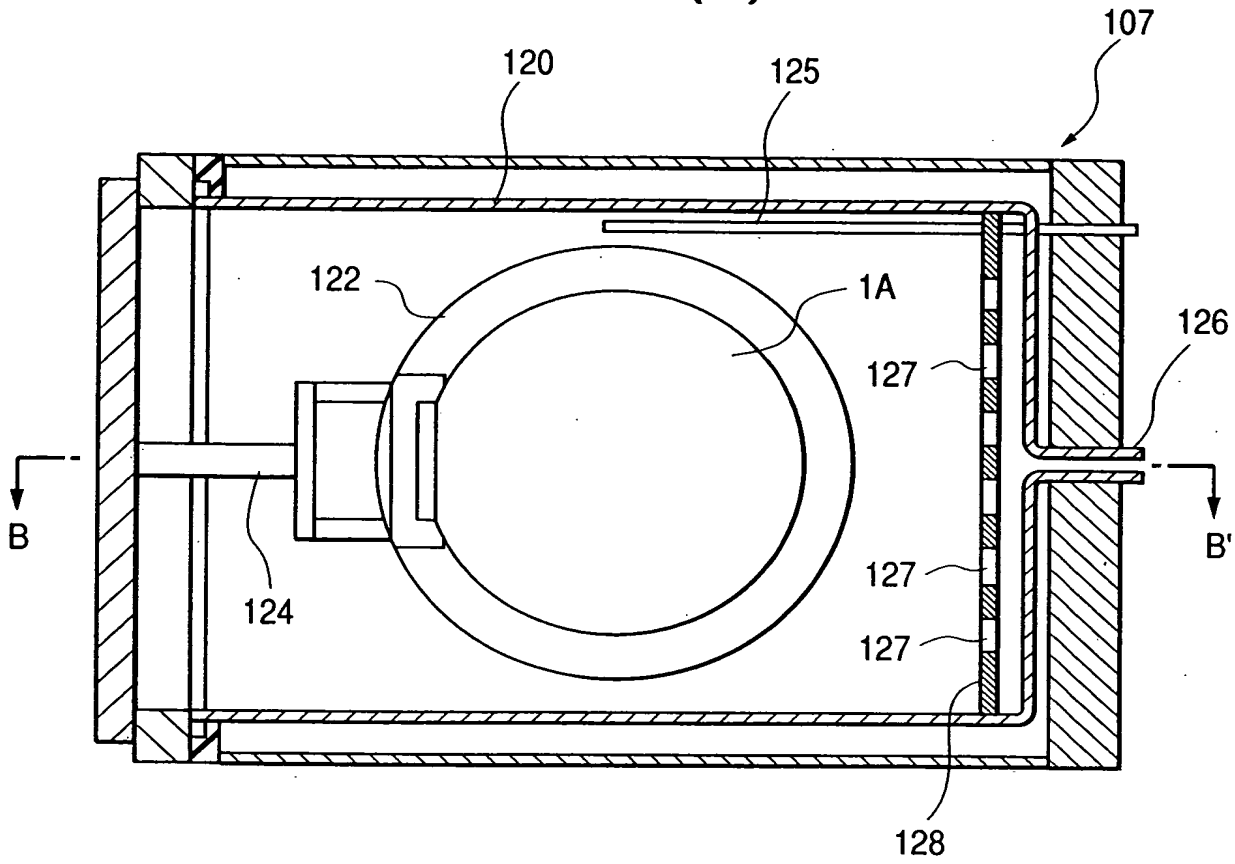

107
120
125
122
1A
126
127
B
B'
124
127
127
128

FIG. 7(b)

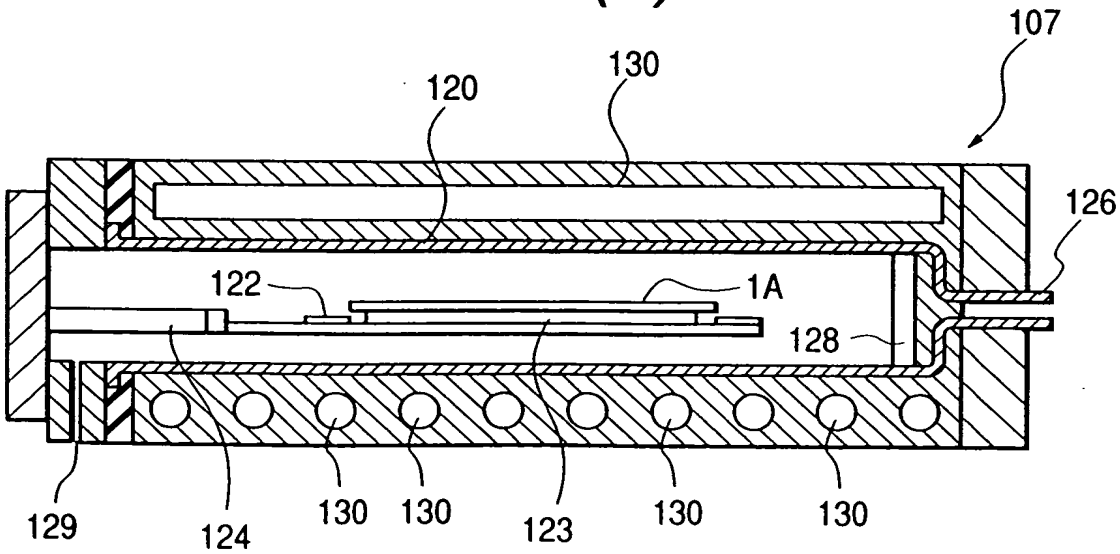

107
130
120
126
122
1A
128
129
124
130
130
123
130
130

FIG. 8

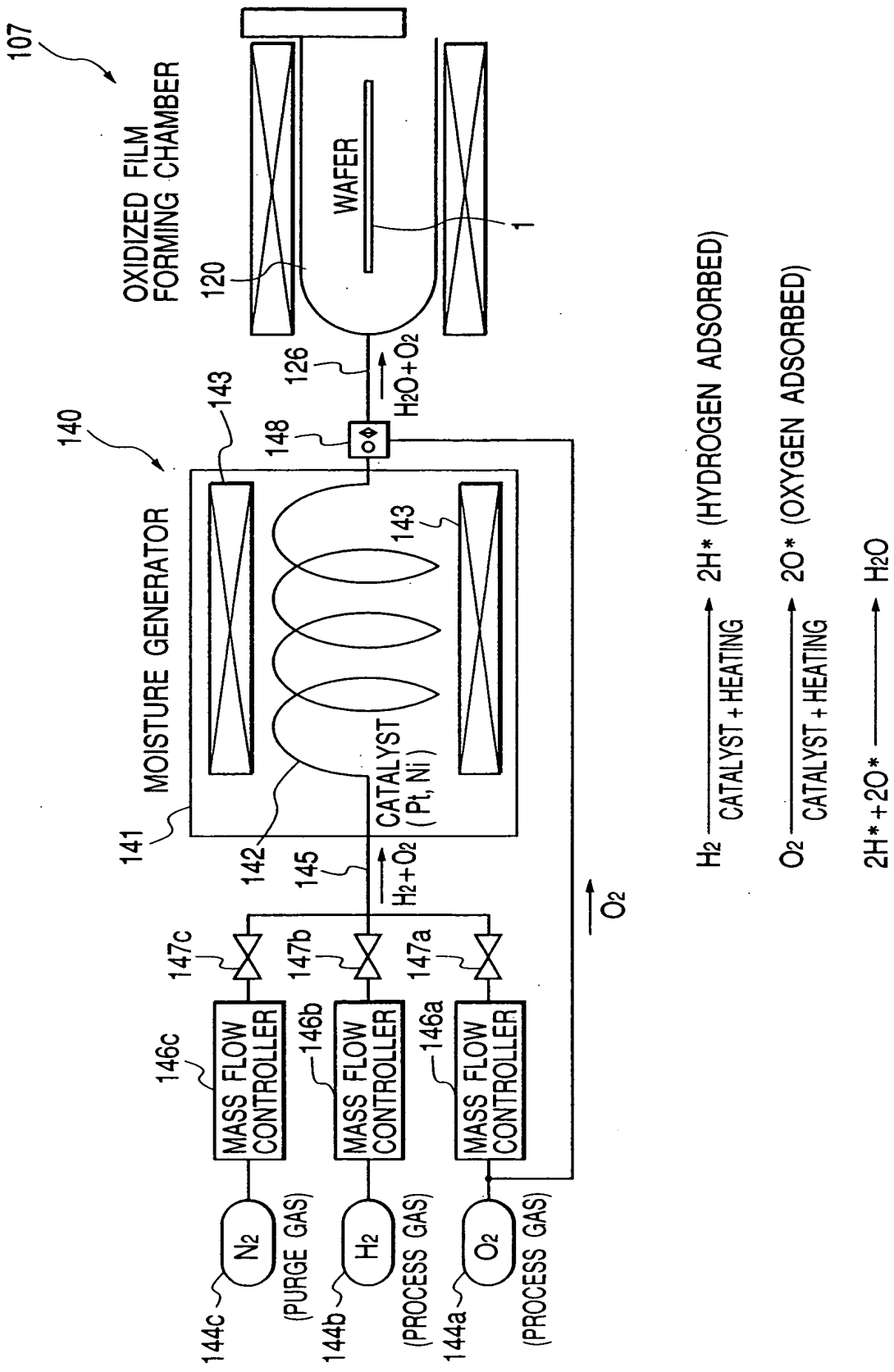

107
OXIDIZED FILM FORMING CHAMBER
120
WAFER
1
126
H_2O+O_2
140
MOISTURE GENERATOR
143
148
143
141
142
145
CATALYST (Pt, Ni)
H_2+O_2
O_2
147c
147b
147a
146c
146b
146a
MASS FLOW CONTROLLER
MASS FLOW CONTROLLER
MASS FLOW CONTROLLER
N_2
H_2
O_2
144c
144b
144a
(PURGE GAS)
(PROCESS GAS)
(PROCESS GAS)
H_2 CATALYST + HEATING $2H^*$ (HYDROGEN ADSORBED)
O_2 CATALYST + HEATING $2O^*$ (OXYGEN ADSORBED)
$2H^* + 2O^*$ H_2O

FIG. 9

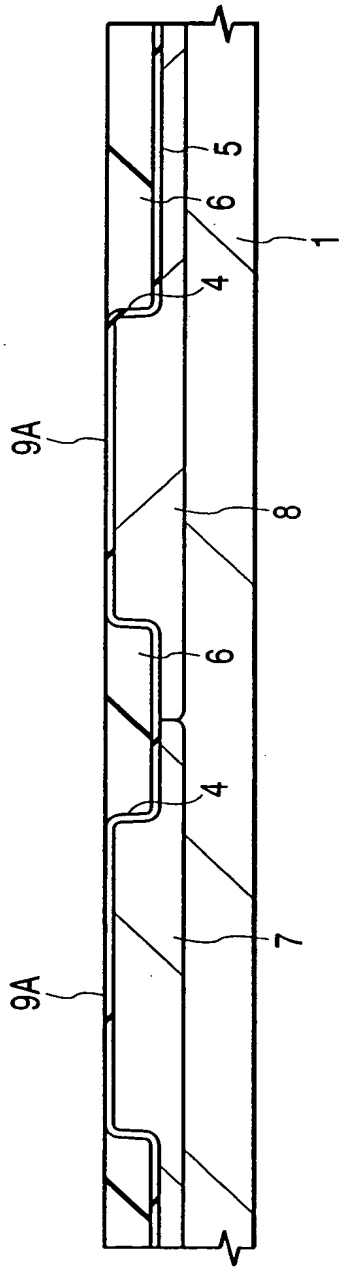


FIG. 10

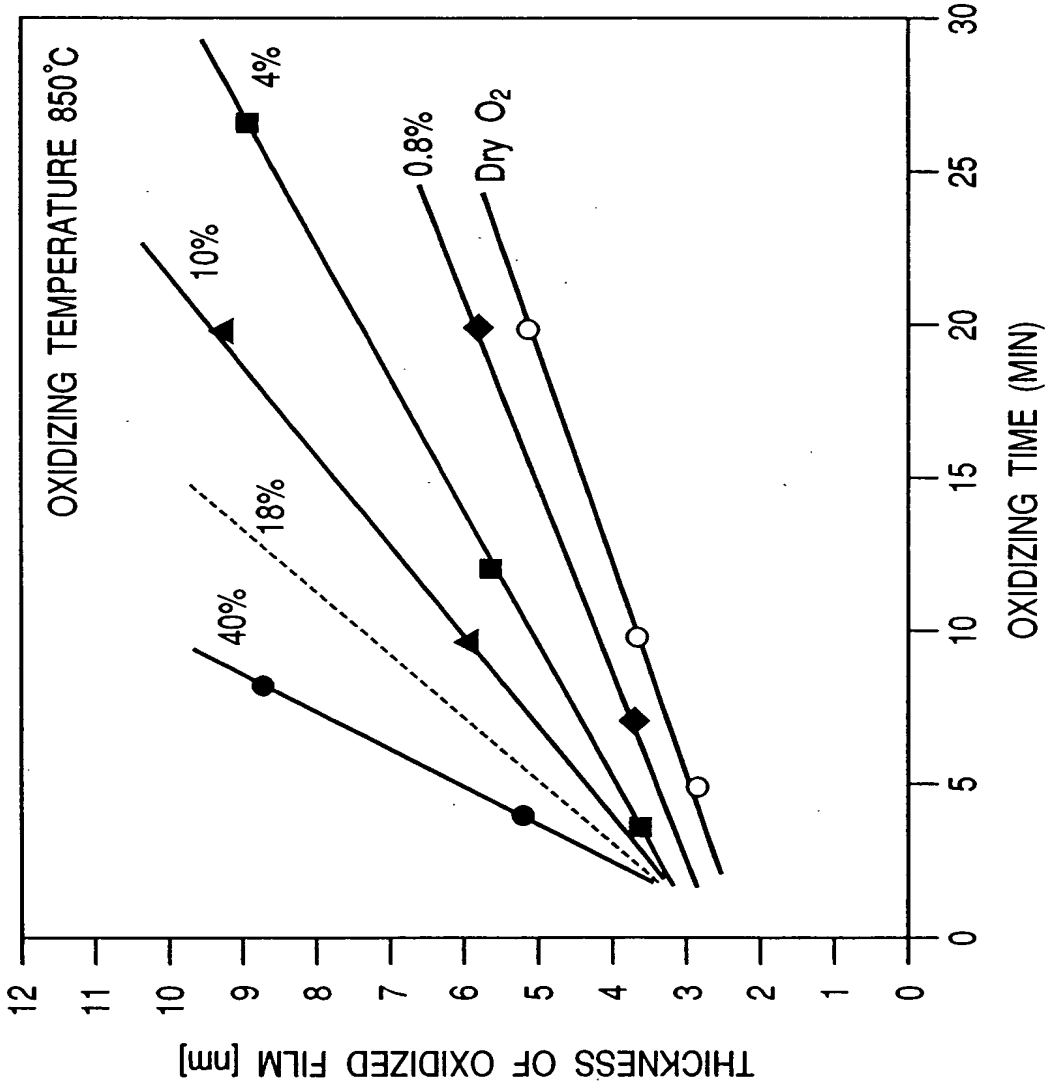

OXIDIZING TEMPERATURE 850°C
40%
18%
10%
4%
0.8%
Dry O_2
THICKNESS OF OXIDIZED FILM [nm]
OXIDIZING TIME (MIN)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
5
10
15
20
25
30

FIG. 11(a)

MOISTURE + OXYGEN GAS MIXTURE

F_W (FLOW RATE OF MOISTURE)
F_O (FLOW RATE OF OXYGEN)

$$\text{MOISTURE CONCENTRATION} = \frac{F_W}{F_O + F_W} \times 100\%$$

FIG. 11(b)

MOISTURE + HYDROGEN GAS MIXTURE

P_W (PARTIAL PRESSURE OF MOISTURE)
P_H (PARTIAL PRESSURE OF HYDROGEN)

$$\text{MOISTURE CONCENTRATION} = \frac{P_W}{P_H} \times 100\%$$

FIG. 12

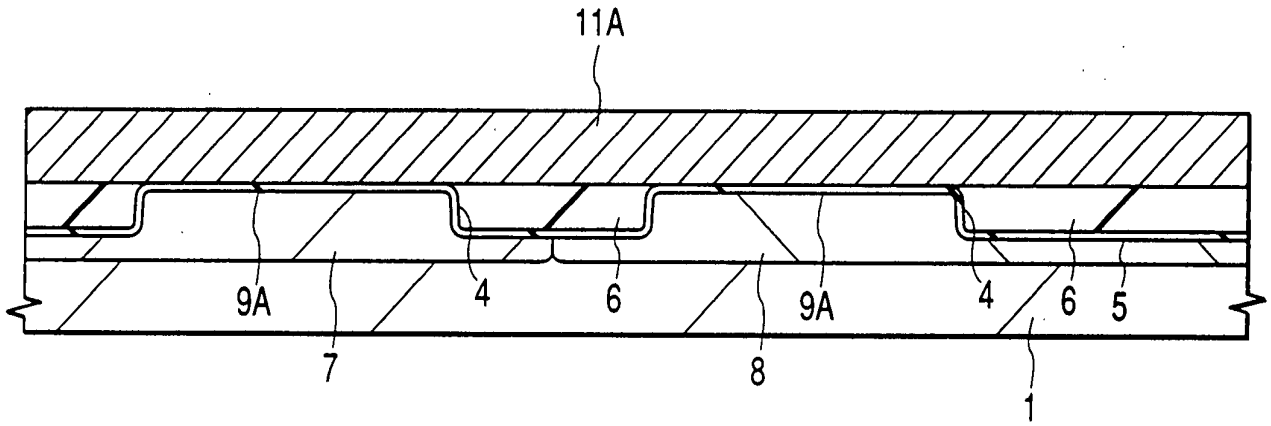
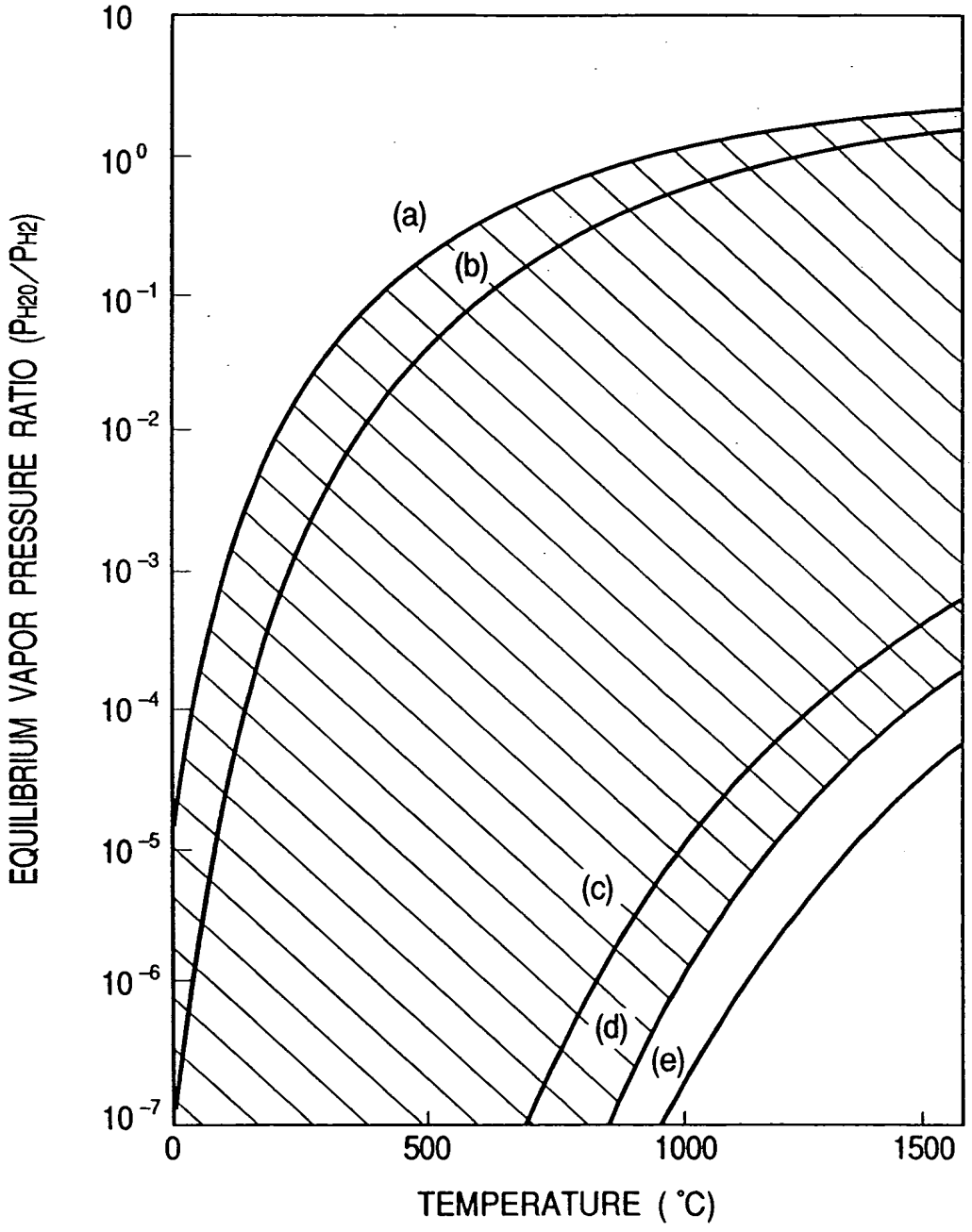


FIG. 13



(a) $W+3H_2O \rightleftarrows WO_3+3H_2$

(b) $Mo+2H_2O \rightleftarrows MoO_2+2H_2$

(c) $2Ta+5H_2O \rightleftarrows Ta_2O_5+5H_2$

(d) $Si+2H_2O \rightleftarrows SiO_2+2H_2$

(e) $Ti+2H_2O \rightleftarrows TiO_2+2H_2$

FIG. 14

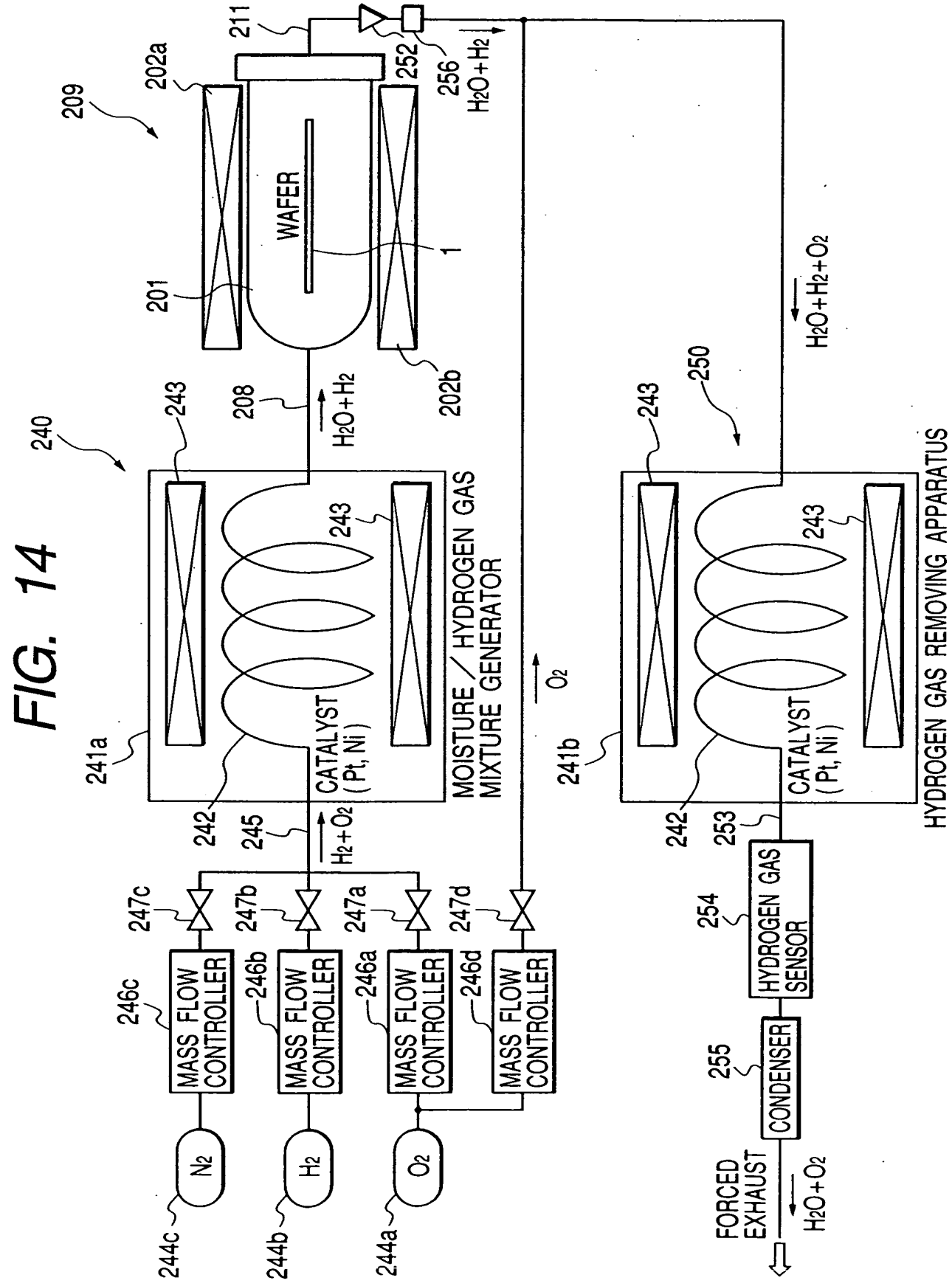

209
202a
211
252
256
H_2O+H_2
WAFER
1
201
202b
208
H_2O+H_2
240
243
243
250
$H_2O+H_2+O_2$
MOISTURE / HYDROGEN GAS MIXTURE GENERATOR
HYDROGEN GAS REMOVING APPARATUS
241a
241b
CATALYST (Pt, Ni)
CATALYST (Pt, Ni)
O_2
242
245
H_2+O_2
242
253
247c
247b
247a
247d
246c
246b
246a
246d
MASS FLOW CONTROLLER
MASS FLOW CONTROLLER
MASS FLOW CONTROLLER
MASS FLOW CONTROLLER
254
HYDROGEN GAS SENSOR
255
CONDENSER
N_2
H_2
O_2
244c
244b
244a
FORCED EXHAUST
H_2O+O_2

FIG. 15

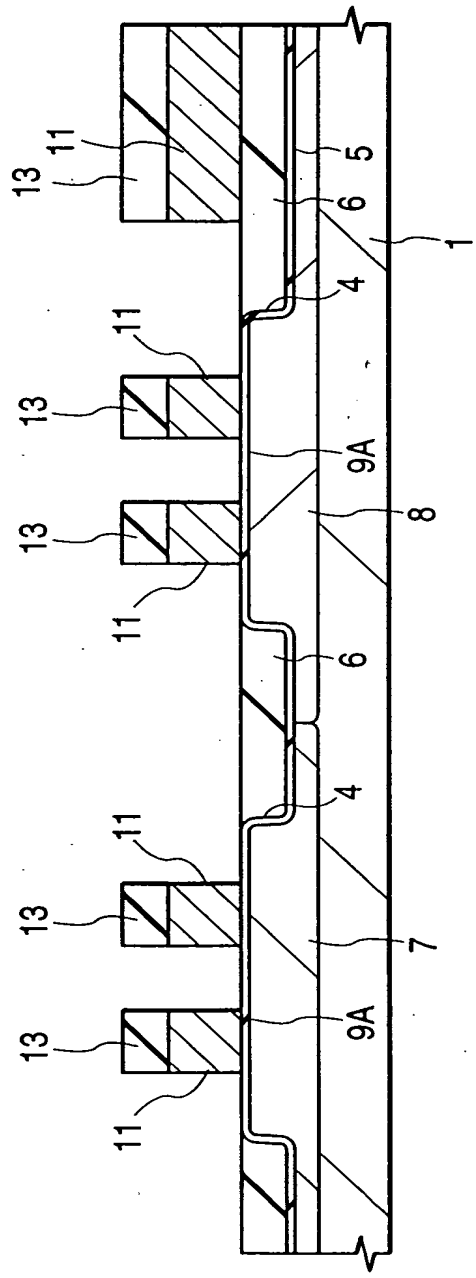


FIG. 16

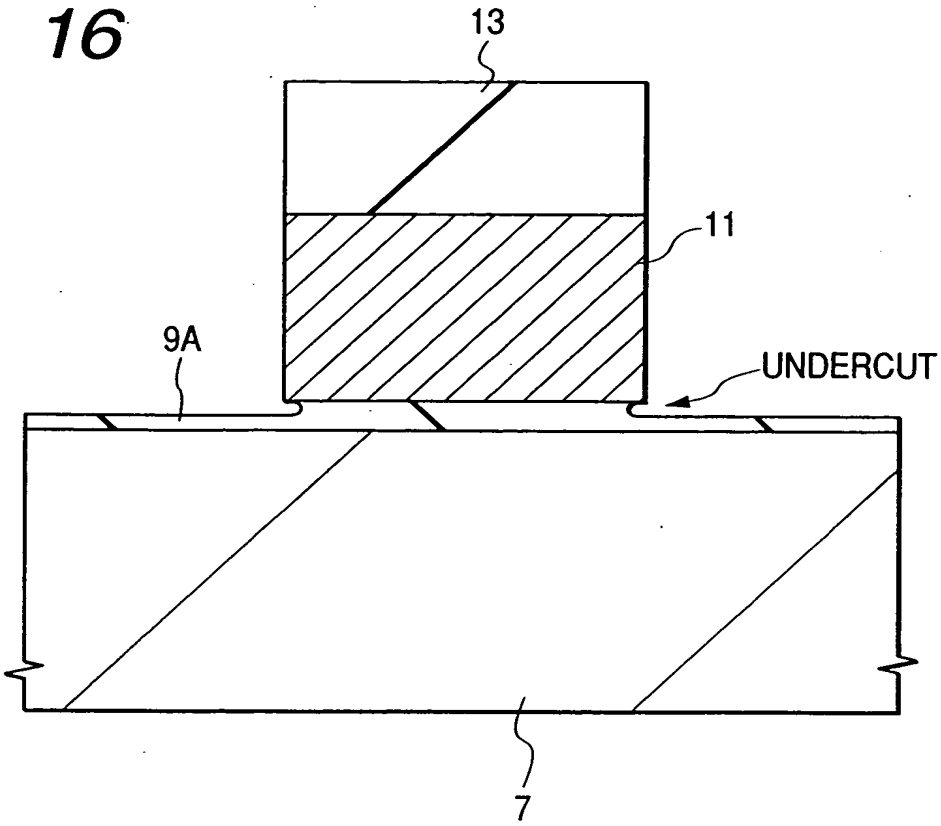


FIG. 17

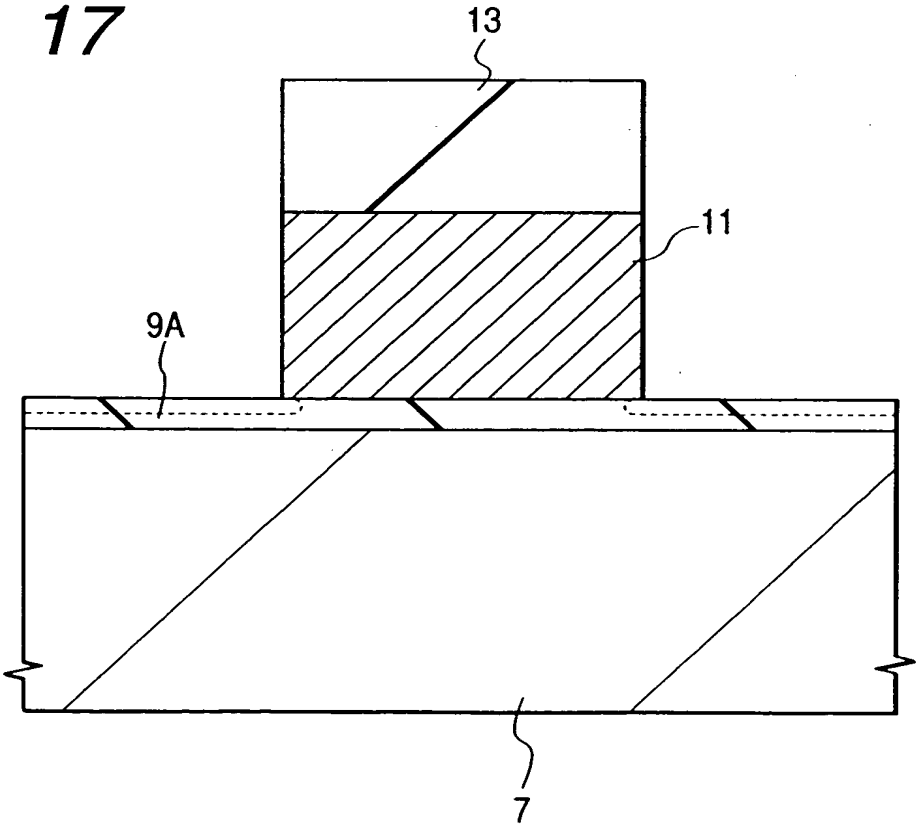


FIG. 18

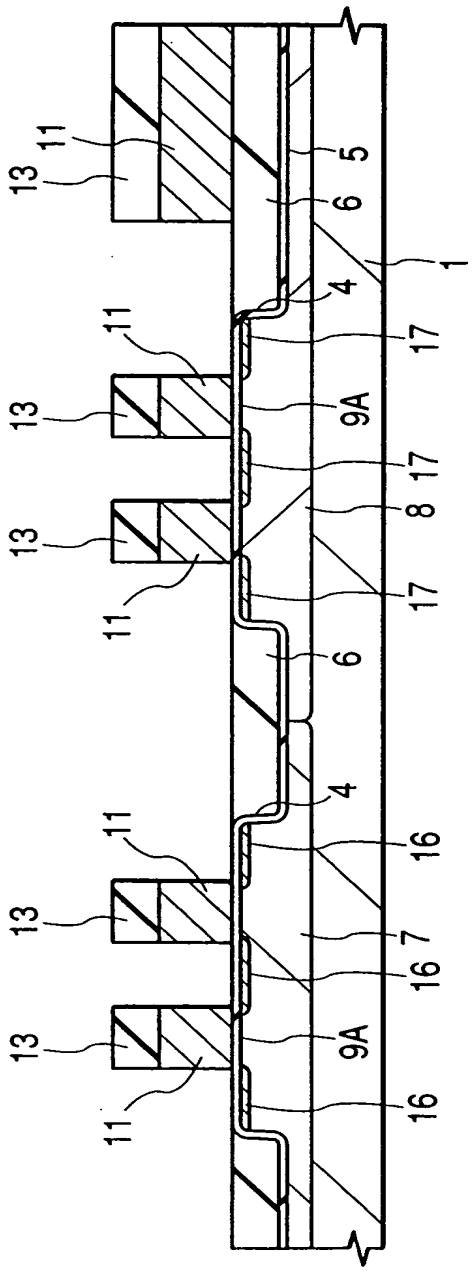


FIG. 19

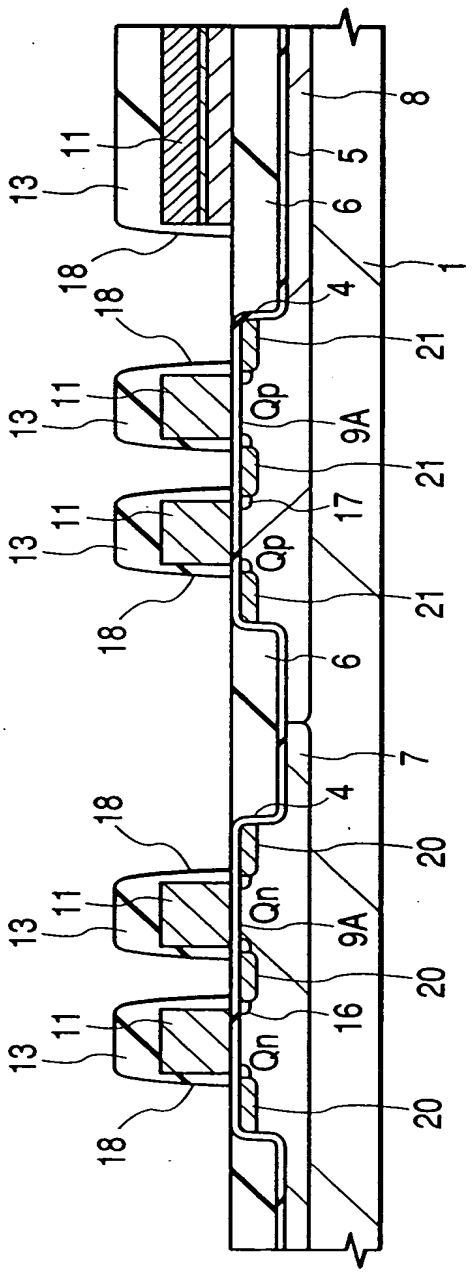


FIG. 20

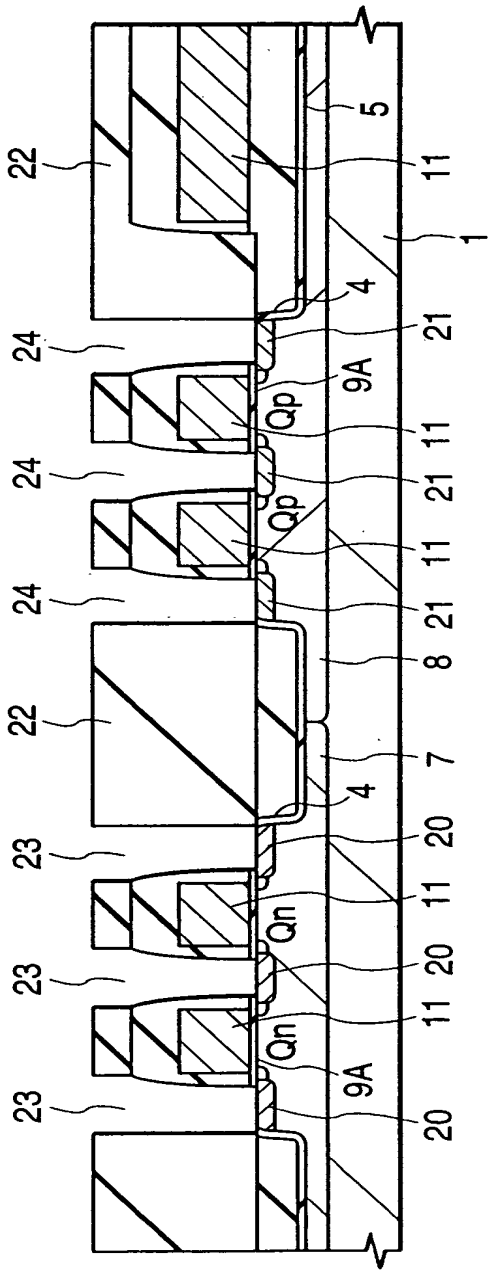

22
24
24
24
24
22
23
23
23
23
5
11
1
4
21
9A
Qp
11
21
11
21
8
7
4
20
11
Qn
20
11
Qn
9A
20

FIG. 21

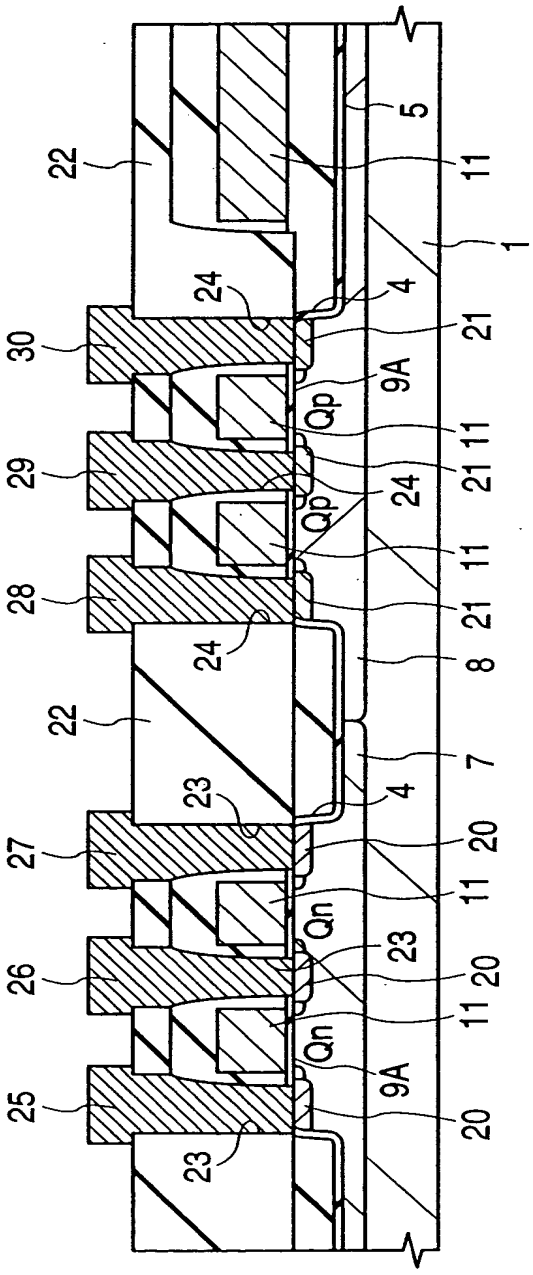

22
30
29
28
24
22
27
26
25
23
5
11
1
24
4
21
9A
Qp
11
21
24
11
21
8
7
4
20
11
Qn
23
20
11
Qn
9A
20

FIG. 22

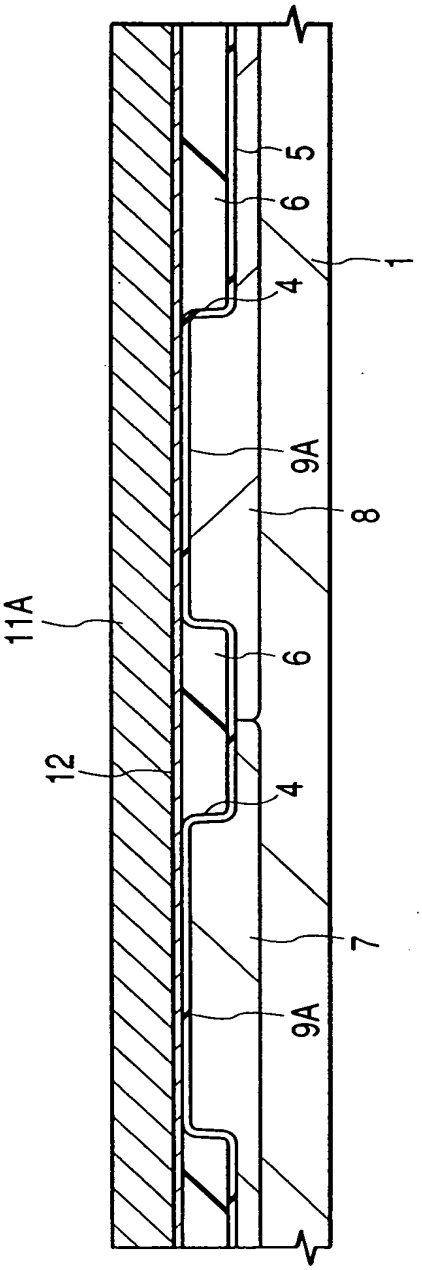

11A
12
4
6
5
1
9A
8
7
9A

FIG. 23

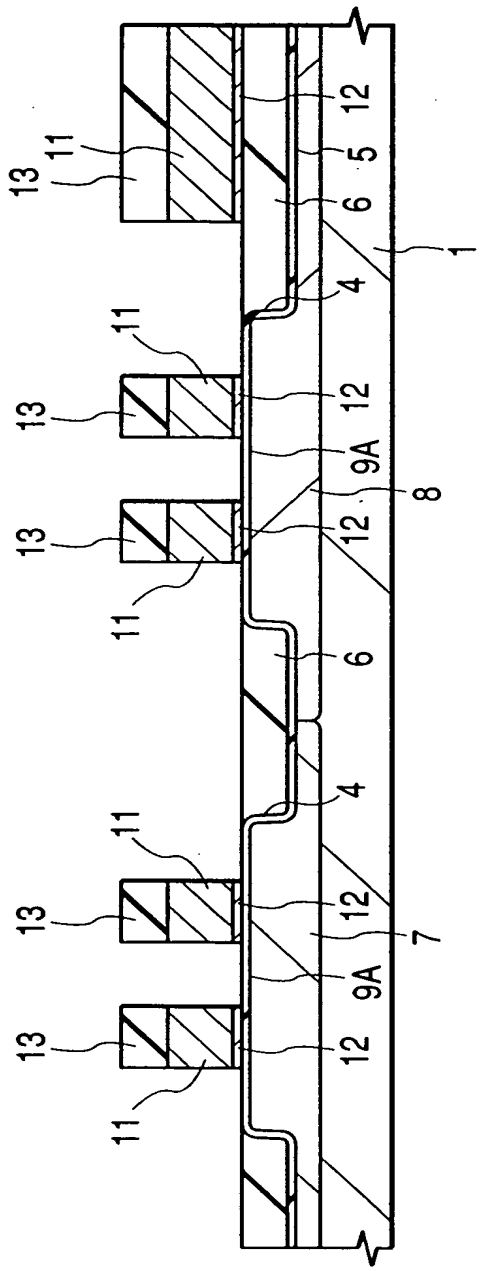

13
11
12
5
6
1
4
11
13
12
9A
8
13
12
11
6
4
11
13
12
7
9A
13
12
11

FIG. 24

$$d_r = \varepsilon_s \sum_i \frac{d_i}{\varepsilon_i}$$

d_r=EFFECTIVE FILM THICKNESS IN SiO_2 TERMS

d_i=THICKNESS OF TARGET INSULATING FILM

ε_s=DIELECTRIC CONSTANT OF SILICON

ε_i=DIELECTRIC CONSTANT OF TARGET INSULATING FILM

FIG. 25

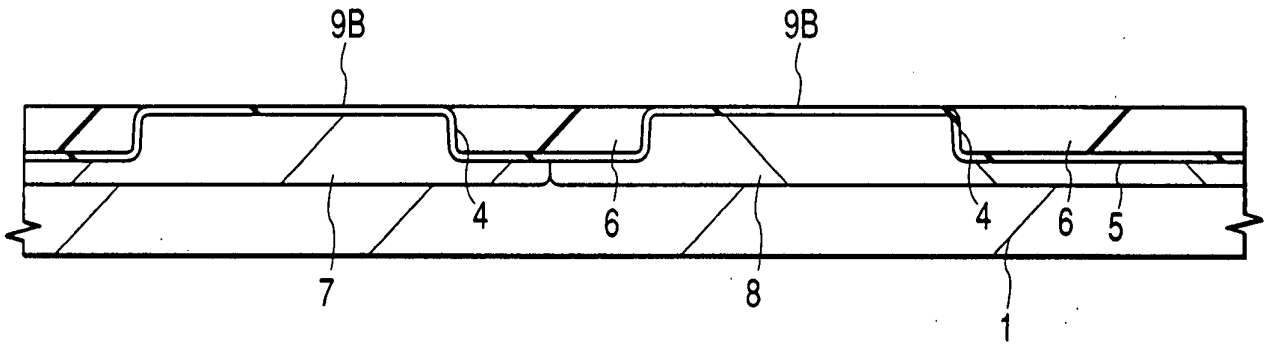


FIG. 26

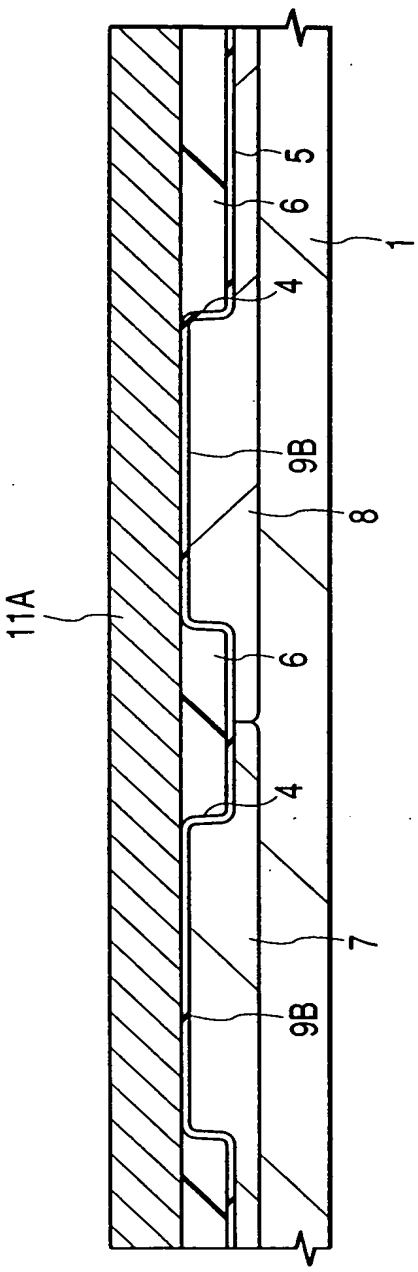


FIG. 27

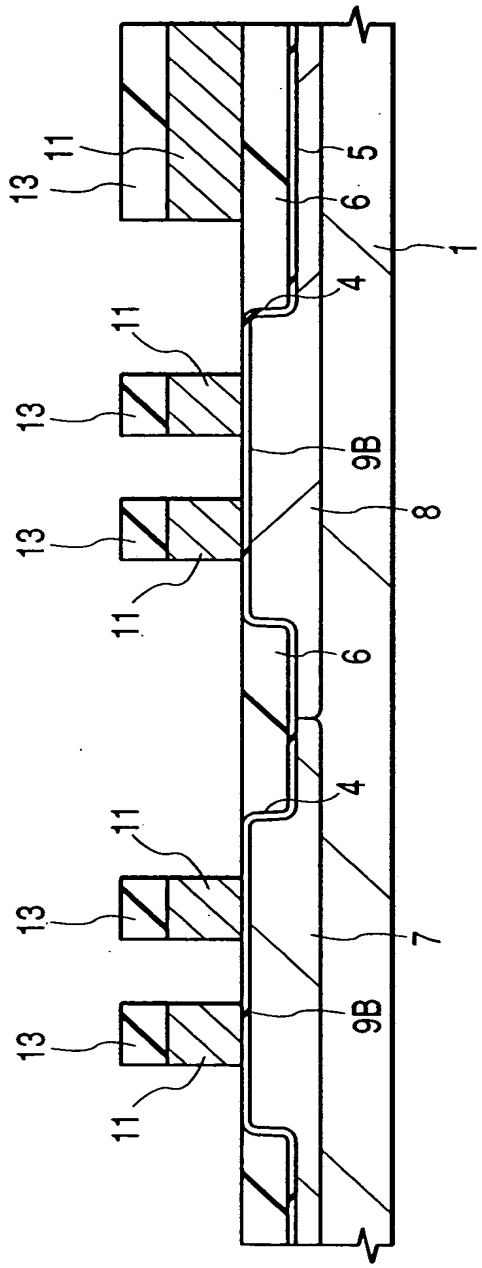


FIG. 28

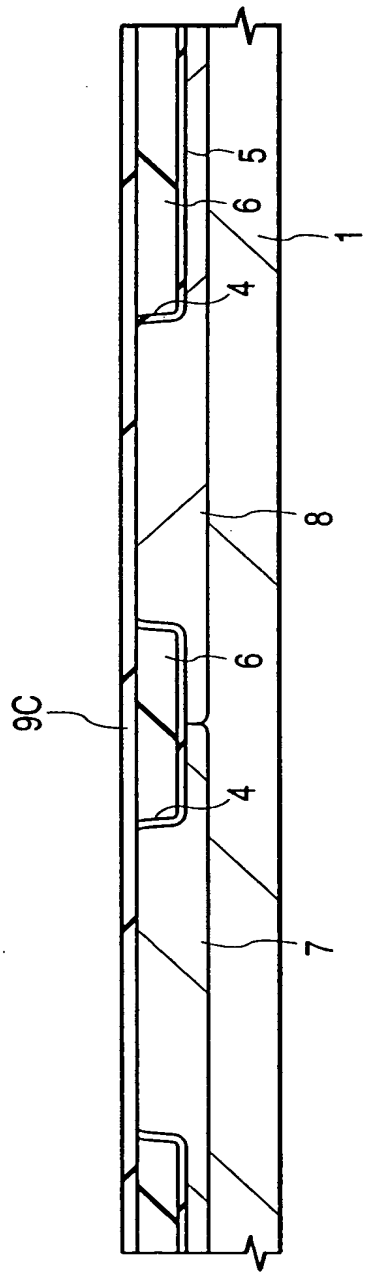


FIG. 29

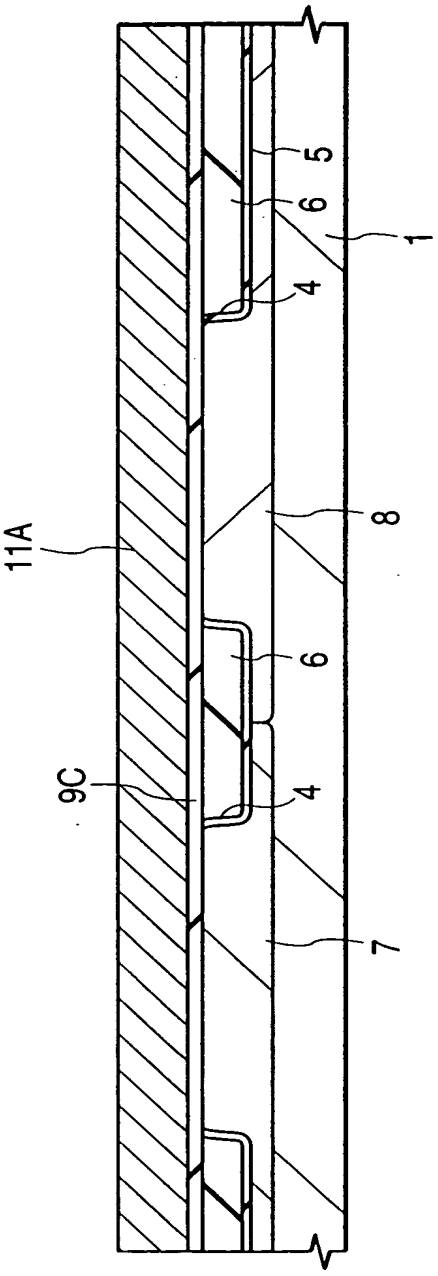


FIG. 30

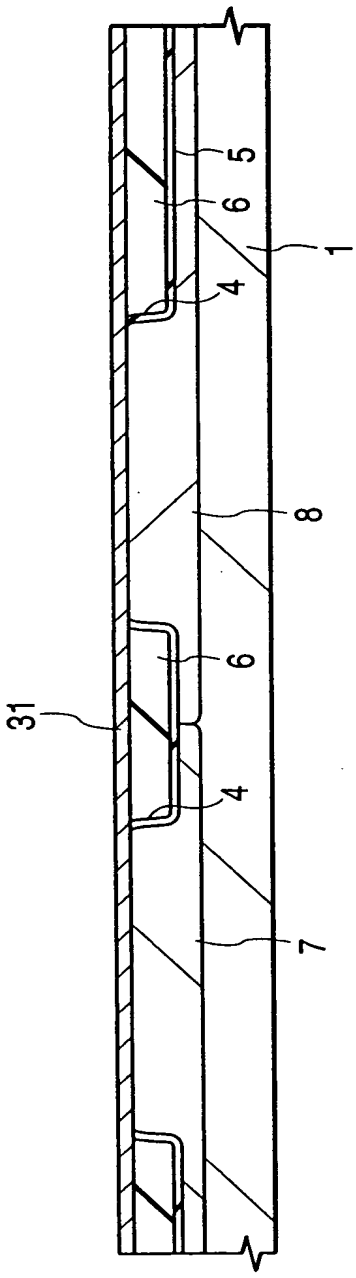


FIG. 31

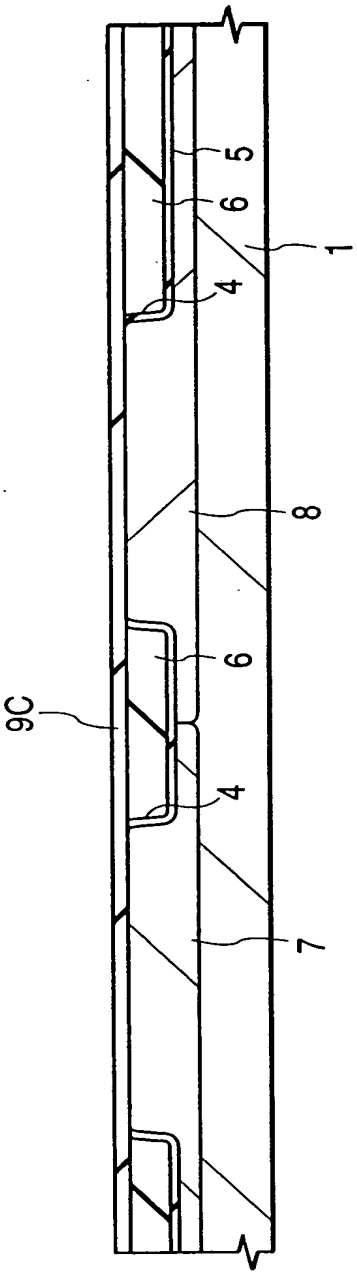


FIG. 32

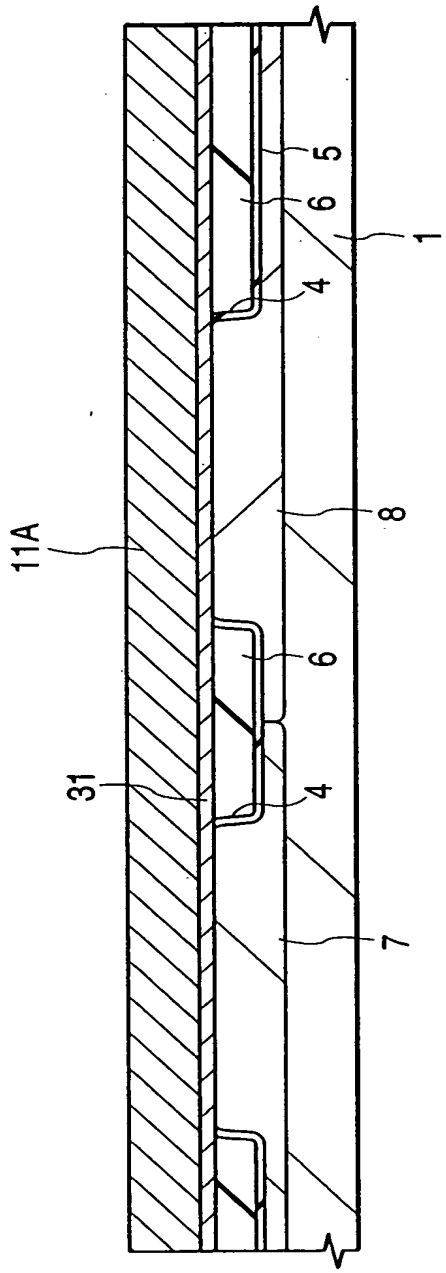


FIG. 33

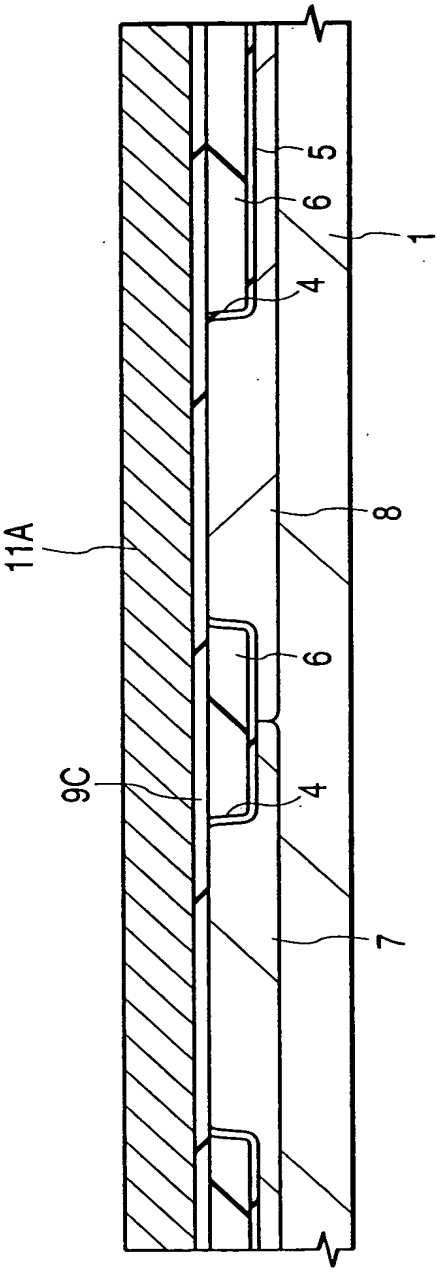


FIG. 34

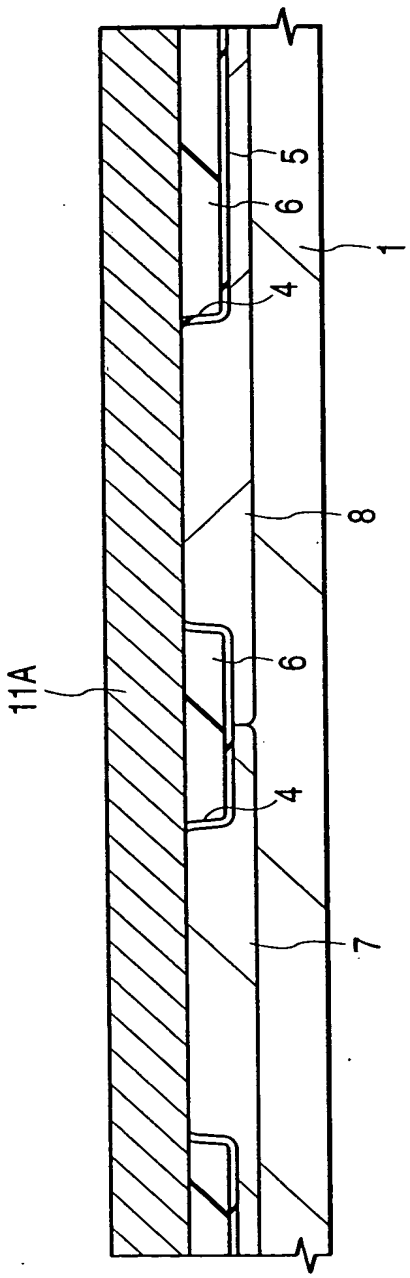
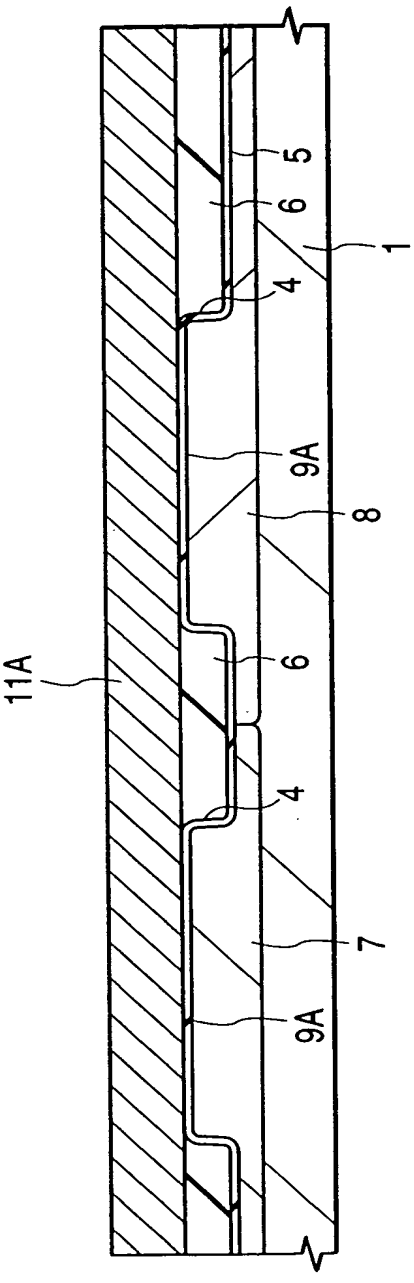


FIG. 35



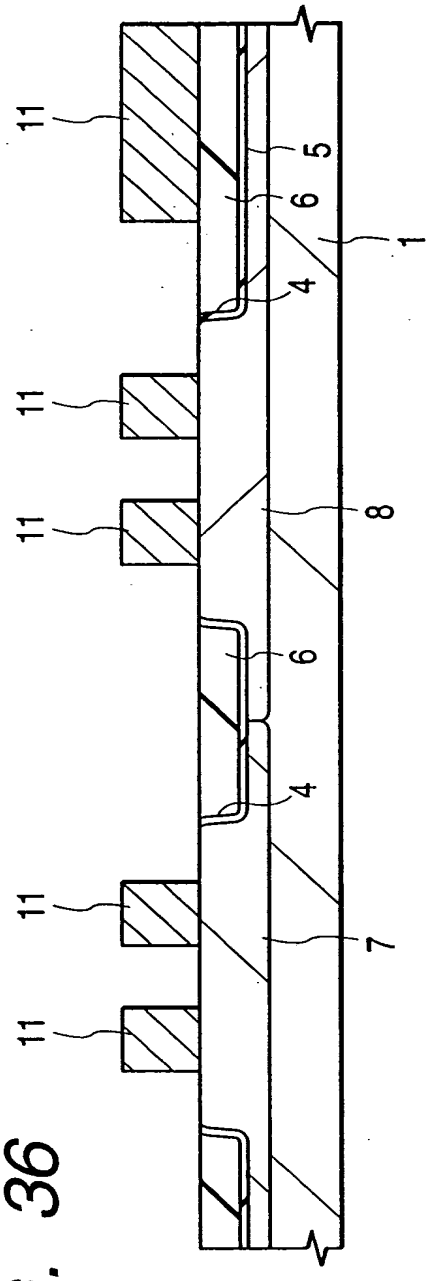


FIG. 36

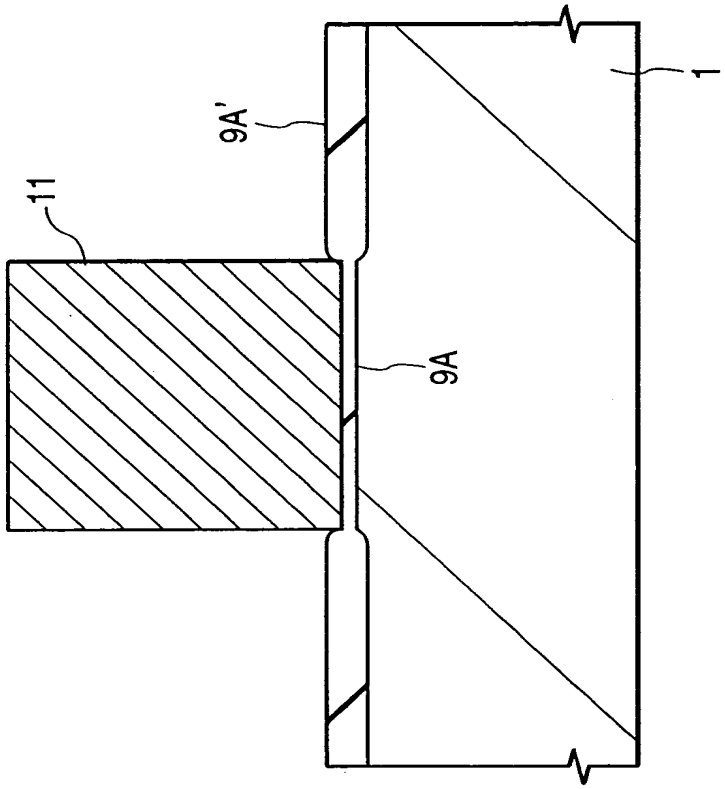


FIG. 37

FIG. 38

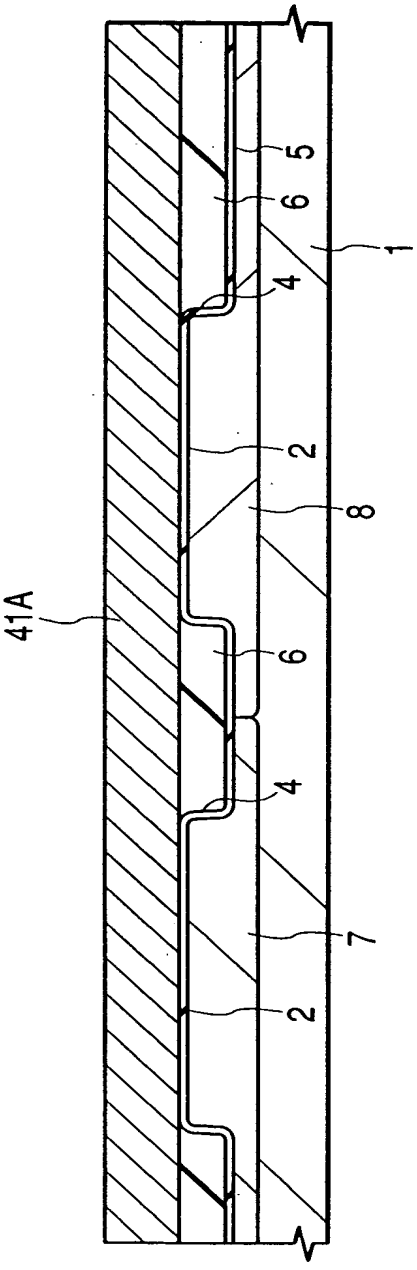

41A
8
2
6
4
7
2
6
5
4
1

FIG. 39

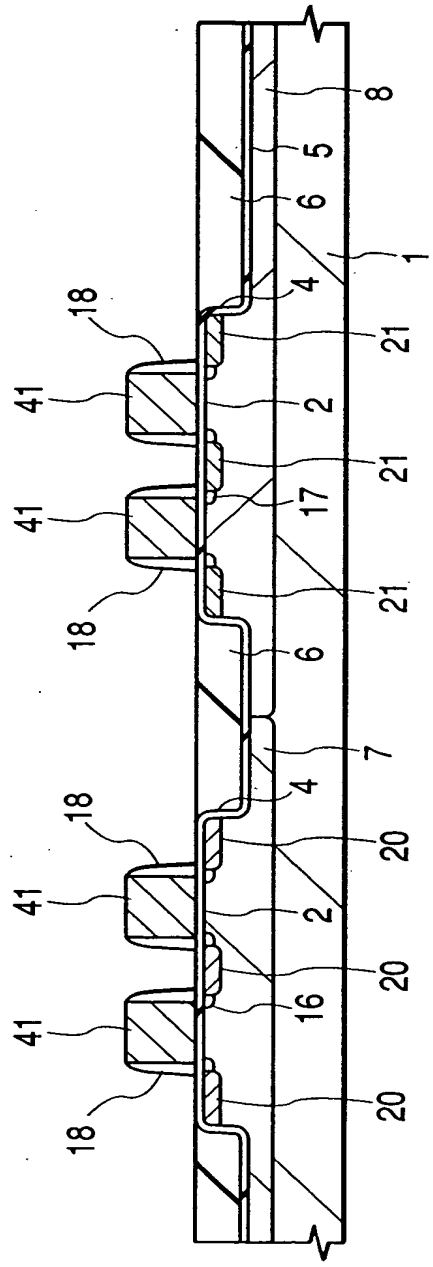

18
41
21
2
21
17
21
18
41
6
7
4
18
41
20
2
20
16
41
20
18
8
5
6
4
1

FIG. 40

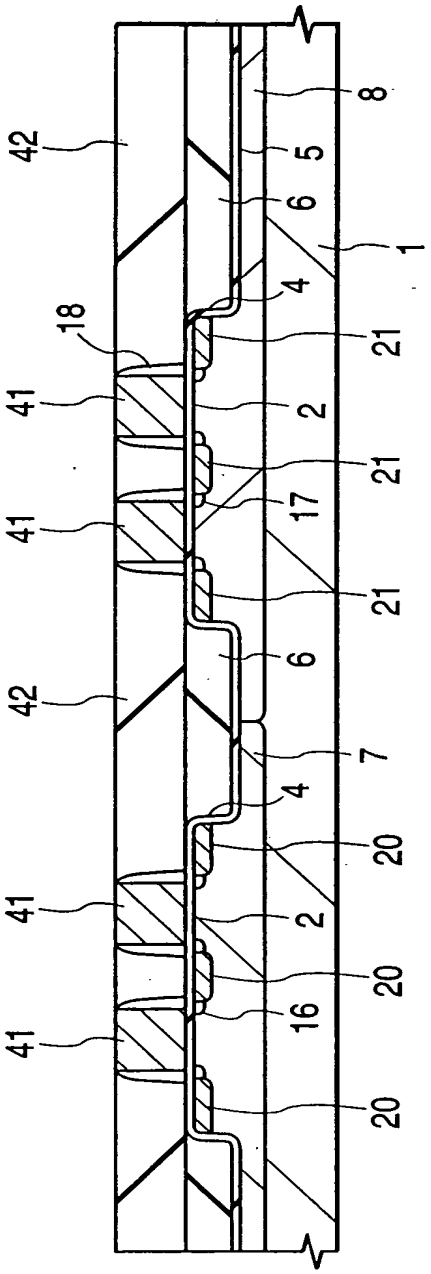

42
41
41
42
41
41
18
8
5
6
1
4
21
2
21
17
21
6
7
4
20
2
20
16
20

FIG. 41

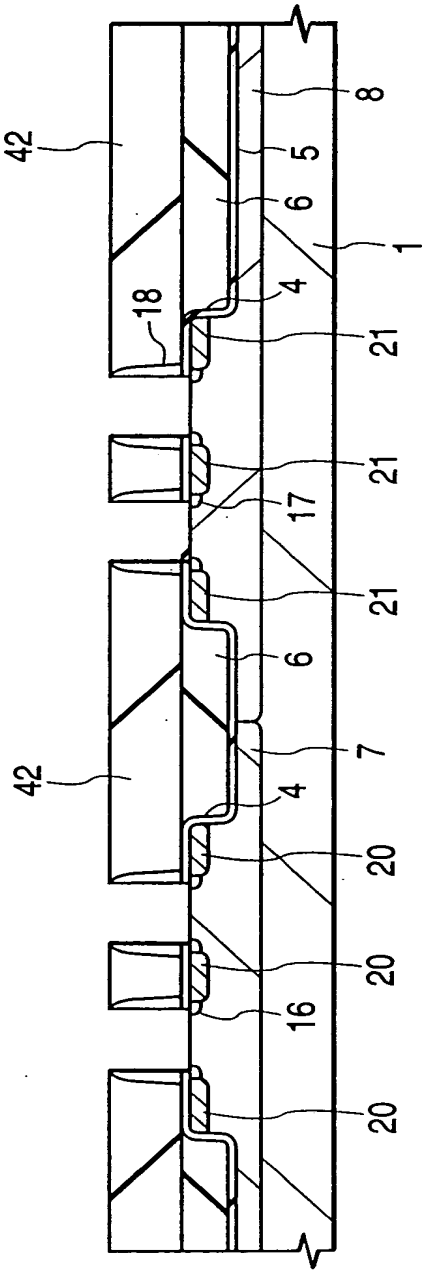

42
42
18
8
5
6
1
4
21
21
17
21
6
7
4
20
20
16
20

FIG. 42

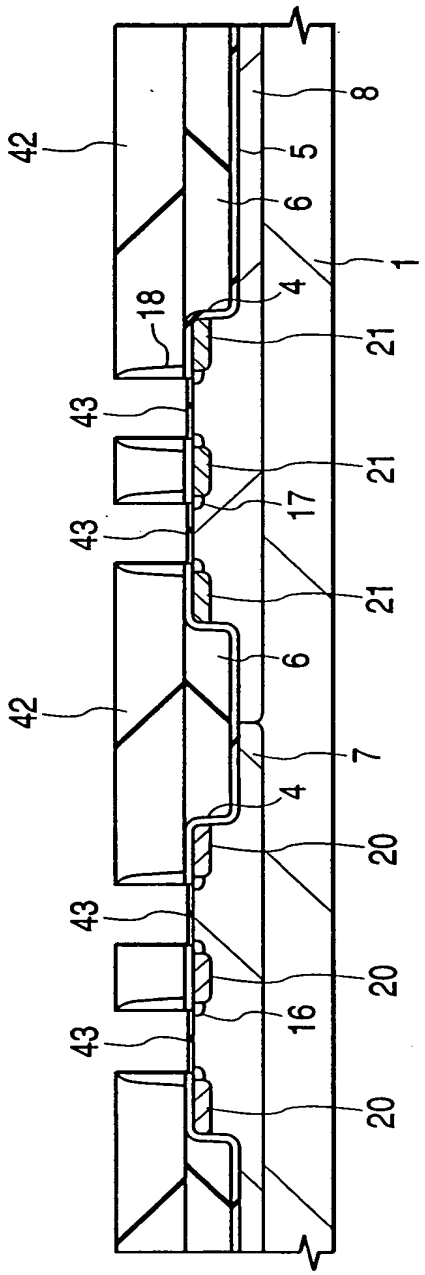

42
8
5
6
1
4
18
21
43
21
17
43
21
42
6
7
4
20
43
20
16
43
20

FIG. 43

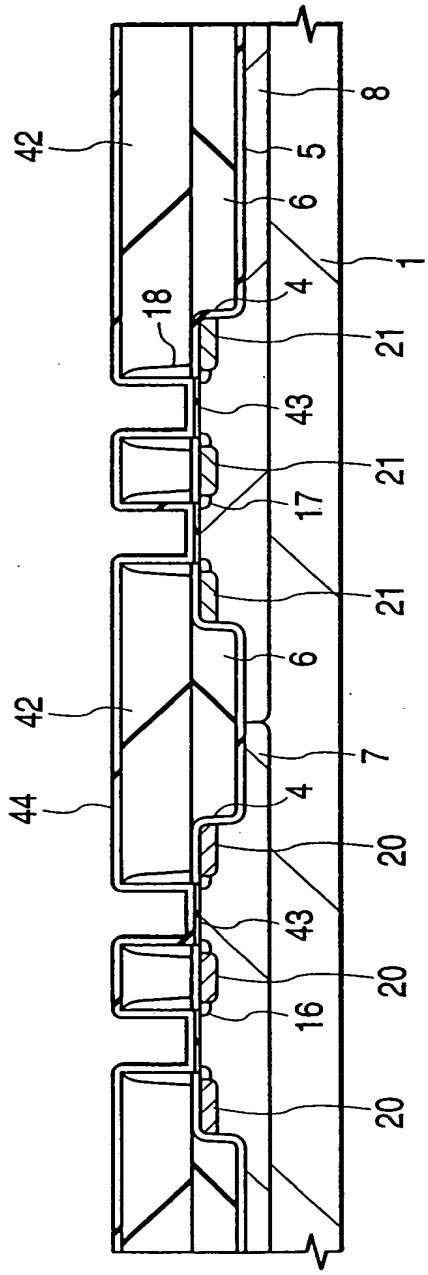

42
8
5
6
1
4
18
21
43
21
17
21
42
6
7
44
4
20
43
20
16
20

FIG. 44

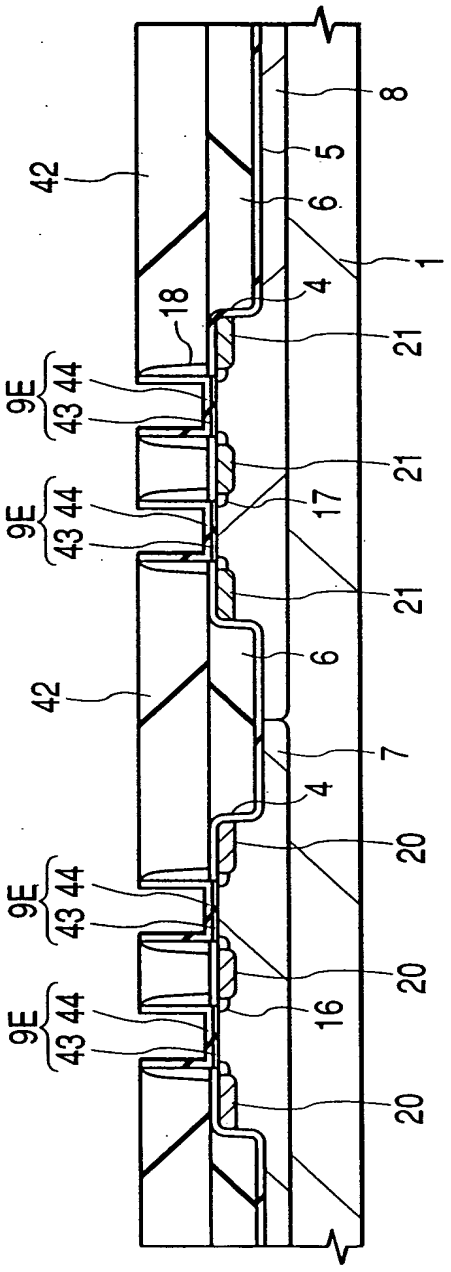


FIG. 45